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Circular No. 783

June 1948 • Washington, D. C.

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Effects of Awns on Yield and Market Qualities of Wheat[1]

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SUMMARY

Awnless Baart and Awned Onas, derived by reciprocal backcrossing from cross of Baart × Onas, were compared in paired guarded-row nursery plot tests at 16 locations in the western United States and 2 in Canada with the original awned Baart and awnless Onas. In general, the awned forms were superior in yield, test weight, and kernel weight under both irrigated and semiarid conditions. Exceptions to the general responses occurred at a few stations, but these showed no relation to observed environmental differences. The possible commercial usefulness of the derived awned Onas is suggested.

The derived-awn types are generally similar to their parental strains in chemical, milling, and baking qualities.

REVIEW OF LITERATURE

This circular is the second report[2] on the effects of awns on the development of the wheat kernel in experiments on a region-wide scale. For the present study, the cross Onas×Baart was backcrossed reciprocally to provide awned and awnless counterparts of the Onas and Baart varieties. Strains derived by backcrossing are especially suited for comparative testing with the original variety and often can be substituted for the older variety in commercial culture.[3] By comparing awned and awnless backcross derivatives the effects of awns can be measured without the mutilation that accompanies awn removal.

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[1] Cooperative investigations of the Division of Cereal Crops and Diseases, Bureau of Plant Industry, Soils, and Agricultural Engineering, Agricultural Research Administration; the Arizona, California, Idaho, Oregon, Montana, Utah, and Washington Agricultural Experiment Stations; and the Cereal Division of the Canadian Department of Agriculture.

[2] Bayles, B. B., and Suneson, C. A. EFFECT OF AWNS ON KERNEL WEIGHT, TEST WEIGHT, AND YIELD OF WHEAT. Amer. Soc. Agron. Jour. 32: 382–388. 1940.

Miller and associates [4] recently presented a comprehensive review of literature dealing with the morphology and the physiological functions of wheat awns. They reported that de-awning immediately after heading decreased kernel weight and weight of grain per head.

MATERIAL AND METHODS

The original Onas×Baart cross was made in 1931, and the first backcrosses to Onas and Baart were made on F_2 plants in 1933. The material was grown and six backcrosses made at Aberdeen, Idaho; Tucson, Ariz., or in the greenhouse at Arlington, Va., during the period 1931 to 1937. In 1937 all stocks were sent to Davis, Calif., where somewhat larger backcross populations were grown in each generation. In the progress of breeding, the awn type was distinguishable in the heterozygous state in the F_1 generation, and in the homozygous and heterozygous condition in the F_3 and later generations.

As finally constituted in 1942, Awnless Baart (C. I. 12236)[5] was made by bulking 9 lines of Onas×Baart ^{10} (italicized superscripts indicate number of times recurrent variety was used as a parent) and 5 lines of Onas×Baart ^{11}, all of which were homozygous for the Onas type of awnlessness. Awned Onas (C. I. 12235) was composited from a bulk of 17 lines of Baart×Onas ^{9} and 7 lines of Baart×Onas ^{10}, all of which were homozygous for the Baart type of awnedness. Onas is sometimes characterized as awnleted. Baart has shorter awns on the basal spikelets than do Turkey and many other awned varieties.

Seed for the tests reported here was provided annually to cooperators from Davis, Calif.; Aberdeen, Idaho; or Pullman, Wash. Acre yield and test weight were recorded by the cooperators at the 18 locations listed in table 1. Plant height and heading data also were recorded. All the experiments were conducted in paired guarded-row nursery plots.

Although these test plots differed in size and in number of replications and the equipment for taking weights or test weights was not equally precise, the experiment was favored by the independent sampling contributions of more than 20 cooperators. The kernel-weight determinations, based on an average sample of 600 kernels each, were made at Davis on grain supplied by the cooperators. Two or more persons sampled for kernel weight each year.

Paired performances are shown in table 2 under the caption "times superior," from which distributions the significance of the difference can be determined readily by the binomial method.

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[3] SUNESON, C. A., RIDDLE, O. C., and BRIGGS, F. N. YIELDS OF VARIETIES OF WHEAT DERIVED BY BACKCROSSING. Amer. Soc. Agron. Jour. 33: 835–840. 1941.

[4] MILLER, E. C., GAUCH, H. G., and GRIES, G. A. A STUDY OF THE MORPHOLOGICAL NATURE AND PHYSIOLOGICAL FUNCTIONS OF THE AWNS OF WINTER WHEAT. Kans. Agr. Expt. Sta. Tech. Bul. 57, 82 pp., illus. 1944.

[5] C. I. refers to accession number of the Division of Cereal Crops and Diseases.

TABLE 1.—*Mean yield per acre, kernel weight, and test weight of normal and synthesized awn types of Baart and Onas wheats during one or more of the 3 years 1943–45*

Location of tests	Baart (awned) vs. Awnless Baart							Awned Onas vs. Onas (awnless)						
	Plots grown	Acre yield		Kernel weight		Test weight		Plots grown	Acre yield		Kernel weight		Test weight	
		Awned	Awnless	Awned	Awnless	Awned	Awnless		Awned	Awnless	Awned	Awnless	Awned	Awnless
	Number	*Bushels*	*Bushels*	*Milligrams*	*Milligrams*	*Pounds*	*Pounds*	*Number*	*Bushels*	*Bushels*	*Milligrams*	*Milligrams*	*Pounds*	*Pounds*
Western United States:														
Mesa, Ariz.[1]	9	50. 5	50. 8	44. 8	43. 8	63. 3	62. 5	13	54. 8	54. 1	43. 5	42. 0	61. 7	60. 8
Davis, Calif	8	45. 1	32. 2	49. 5	43. 7	62. 8	60. 3	8	38. 9	35. 5	40. 9	36. 4	58. 9	57. 3
Prosser, Wash.[1]	9	58. 7	53. 8	52. 5	52. 1	63. 1	62. 6	8	65. 5	66. 0	49. 8	45. 7	61. 2	60. 5
Aberdeen, Idaho [1]	15	73. 3	69. 7	49. 8	48. 2	63. 5	62. 7	15	86. 9	82. 5	44. 4	43. 1	61. 0	60. 0
Logan, Utah [1]	10	54. 2	49. 5	44. 7	44. 9	60. 3	59. 8	10	68. 7	61. 9	42. 1	40. 7	59. 5	59. 3
Bozeman, Mont.[1]	9	51. 6	45. 5	47. 6	45. 8	64. 0	62. 9	9	60. 9	58. 1	42. 1	39. 5	60. 9	60. 5
Moscow, Idaho	11	35. 0	32. 2	39. 4	36. 0	60. 7	60. 4	11	37. 5	35. 7	36. 5	32. 2	57. 6	56. 4
Pullman, Wash	12	52. 5	50. 0	41. 3	39. 3	62. 5	61. 7	18	60. 7	58. 9	35. 8	33. 9	59. 7	59. 1
Walla Walla, Wash	6	44. 8	44. 3	40. 4	39. 4	61. 6	60. 7	9	50. 7	49. 5	37. 6	35. 2	60. 1	59. 5
Pendleton, Oreg	8	35. 4	29. 7	43. 3	40. 6	62. 8	61. 1	9	41. 6	40. 9	40. 7	37. 0	59. 8	58. 8
Union, Oreg	8	54. 2	47. 1	45. 2	44. 1	------	------	6	59. 8	56. 4	41. 1	39. 6	------	------
Tetonia, Idaho	8	25. 1	22. 9	37. 1	36. 9	56. 3	56. 3	9	32. 1	31. 3	36. 5	34. 2	58. 0	57. 3
Sandpoint, Idaho	4	34. 0	32. 2	43. 2	40. 7	------	------	4	33. 4	32. 8	37. 7	33. 8	------	------
Pomeroy, Wash	6	14. 1	11. 3	------	------	53. 9	50. 0	6	20. 0	19. 0	------	------	53. 5	52. 5
Lind, Wash	6	24. 5	23. 3	33. 3	30. 0	57. 8	56. 0	9	30. 2	28. 8	34. 7	30. 8	57. 1	56. 0
Moro, Oreg	10	25. 4	22. 9	32. 4	30. 2	55. 9	53. 3	10	31. 8	31. 8	29. 5	26. 5	54. 5	53. 4
Canada:														
Ottawa, Ontario	4	34. 7	26. 8	38. 5	40. 0	62. 0	62. 0	4	14. 7	20. 9	28. 1	26. 4	55. 0	53. 5
Lethbridge, Alberta	4	68. 2	60. 9	48. 6	53. 0	62. 0	62. 5	4	97. 4	90. 7	46. 6	48. 0	61. 5	61. 0

[1] Irrigated stations.

TABLE 2.—*Annual and weighted mean yield, kernel weight, and test weight of contrasted awn types of Baart and Onas wheats*

Item	1943		1944		1945		Weighted mean		*t* value
	Awned	Awnless	Awned	Awnless	Awned	Awnless	Awned	Awnless	
Baart vs. Awnless Baart:									
Mean yield bushels	53. 6	47. 0	47. 6	43. 5	37. 7	35. 0	43. 5	39. 4	
Times superior number	27	12	42	8	38	19	107	39	5. 6
Kernel weight milligram	44. 7	42. 6	45. 0	43. 3	39. 6	38. 6	43. 1	41. 5	
Times superior number	33	6	24	6	37	10	94	22	6. 7
Test weight pound	61. 7	60. 4	61. 8	60. 9	60. 5	59. 4	61. 2	60. 1	
Times superior number	13	0	11	2	12	2	36	4	5. 2
Awned Onas vs. Onas:									
Mean yield bushels	57. 5	54. 1	51. 1	49. 7	43. 7	42. 6	49. 6	47. 8	
Times superior number	35	18	32	19	33	25	100	62	3. 0
Kernel weight milligram	41. 0	38. 4	41. 4	38. 4	36. 6	34. 0	39. 6	36. 8	
Times superior number	36	3	30	3	46	1	112	7	9. 6
Test weight pound	59. 8	59. 0	59. 7	58. 9	57. 9	47. 0	59. 1	58. 2	
Times superior number	12	1	12	2	13	1	37	4	5. 2

AWN INHERITANCE

The inheritance studies of the awn characters in the cross Onas×Baart and its backcrosses revealed a two-factor difference. Among 80 backcross F_2 plants selected as awned segregates in 1941, 24 subsequently proved to be homozygous for the full-awn type of Baart. Similarly, among 209 awnleted backcross F_2 plants, 14 subsequently proved to be homozygous for the awnless condition as found in Onas.

The populations in these backcross generations were smaller than in previously reported backcrossing experiments in California, but a greater number of backcrosses were made. It is likely that these wheats constitute at least as complete a genetic duplication of the recurrent parents as was achieved with the previously studied and nondifferentiable Baart 38 and White Federation 38.[6] [7] In this case, however, it was possible to establish averages showing that Awnless Baart is 1.7 inches taller and two-thirds of a day later in heading than Baart. Awned Onas, on the other hand, averaged 0.4 inch shorter and two-thirds of a day earlier in heading than Onas. The expression in one case is transgressive and in the other it is intermediate.

The occurrence of these associations in both populations and the frequency of their detection under diverse environments indicate that the awnless types tend to be taller and later than the awned strains. This suggests a linkage relationship. Although these differences in behavior appear to be genetically significant, they are detectable only because of the great number of observations and probably do not exert a significant effect on yield or weight of the grain.

ENVIRONMENTAL EFFECTS

The data reported in table 1 are not sufficiently extensive to determine the varietal response at individual stations. Yields, kernel weights, and test weights were higher for the awned than for the awnless type of both Baart and Onas at most stations. At Mesa, Ariz., the yields of awned Baart was slightly less than that of awnless Baart, and at Prosser, Wash., the yield of awned Onas was slightly less than that of awnless Onas. Kernel weight and test weight showed increases typical for the awned types at other stations. At Ottawa, Canada, awned Onas yielded significantly less than awnless Onas. No explanation for this is apparent.

At Logan, Utah, and Lethbridge and Ottawa, Canada, the kernel weight of Baart and at Lethbridge, Canada, the kernel weight of Onas digressed from the usual behavior. At Lethbridge the test weight of Baart also digressed. In view of the limited number of samples, it seems reasonable to treat these and other deviations as being due to sampling error. The effects of awns seemed to be independent of soil moisture supply. The indicated advantage for awns in yield, kernel weight, and test weight was about the same at the irrigated stations as at the low-rainfall stations—Moro, Pomeroy, and Lind. Furthermore, a similar divergence in response occurred during the earlier period, when bulk composites of Baart×Onas were under test.[8]

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[6] See footnote 3.

[7] RIDDLE, O. C., and BAKER, G. A. BIASES ENCOUNTERED IN LARGE-SCALE YIELD TESTS. Hilgardia 16: 1–14. 1944.

[8] See footnote 2.

TABLE 3.—*Chemical, milling, and baking data of awned and awnless strains of Baart and Onas*

Item	Baart							
	1943		1944		1945		Average	
	Awned	Awnless	Awned	Awnless	Awned	Awnless	Awned	Awnless
Analysis of wheat:								
U. S. Grade [1]	1 HWh	1 HWh	1 HWh	1 HWh	2 HWh	2 HWh	----------	----------
Hard kernels ... percent	95	93	90	90	88	90	91	91
Protein ... percent [2]	11. 5	11. 4	11. 0	10. 9	12. 9	12. 7	11. 8	11. 7
Particle-size index ... percent	30. 4	24. 8	27. 2	26. 4	27. 6	26. 4	28. 4	25. 9
Doughball time ... minutes	56	51	47	49	42	42	48	47
Analysis of flour:								
Protein ... percent [2]	10. 3	10. 0	9. 7	9. 5	11. 3	10. 9	10. 4	10. 1
Ash ... percent [2]	. 51	. 61	. 35	. 33	. 46	. 47	. 44	. 47
Yellow-loaf cake:								
Volume ... cubic centimeters	940	962	1, 009	962	980	992	976	972
Grain and texture ... score	110	105	100	100	100	95	103	100
Cookie test:								
Factor ... W/T [3]	4. 92	4. 72	5. 49	5. 12	4. 92	4. 75	5. 11	4. 86
Bread:								
Absorption ... percent	54. 0	56. 0	54. 0	54. 0	54. 0	54. 0	54. 0	55. 0
Loaf volume ... cubic centimeters [4]	503	472	683	666	592	600	593	579
Grain and texture ... score [5]	55P	50VP	90VG	85VG	75G	80G	73	72
Crumb color ... score [6]	80Cr	60Cy	85Cr	85Cr	75Cr	80Cr	80	75

Item	Onas							
	1943		1944		1945		Average	
	Awned	Awnless	Awned	Awnless	Awned	Awnless	Awned	Awnless
Analysis of wheat:								
U. S. Grade [1]	1 SWh	1 SWh	1 HWh	1 SWh	2 SWh	2 SWh	----------	----------
Hard kernels____percent	60	72	81	73	59	64	67	70
Protein____percent [2]	9. 7	9. 5	9. 7	9. 7	10. 7	10. 9	10. 0	10. 0
Particle-size index____percent	30. 0	29. 2	27. 2	26. 8	28. 8	29. 6	28. 7	28. 5
Doughball time____minutes	127	120	121	113	108	120	119	118
Analysis of flour:								
Protein____percent [2]	8. 4	8. 2	8. 5	8. 7	9. 2	9. 5	8. 7	8. 8
Ash____percent [2]	. 49	. 56	. 38	. 38	. 47	. 46	. 45	. 47
Yellow-loaf cake:								
Volume____cubic centimeters	910	922	1, 021	1, 099	986	968	972	966
Grain and texture____score	105	105	105	95	100	95	103	98
Cookie test:								
Factor____W/T [3]	5. 26	5. 74	5. 70	5. 99	5. 12	4. 76	5. 36	5. 50
Bread:								
Absorption____percent	54. 0	54. 0	54. 0	54. 0	54. 0	54. 0	54. 0	54. 0
Loaf volume____cubic centimeters	512	530	692	726	649	677	618	644
Grain and texture____score [5]	65F	60P	85G	85VG	85G	90VG	78	78
Crumb color____score [6]	70Cr	70Cr	80Cr	80Cr	75Cr	75Cr	75	75

[1] HWh=Hard White; SWh=Soft White.

[2] Data on 14.0-percent moisture basis.

[3] W/T, ratio of width to thickness.

[4] Optimum volume.

[5] Texture: VP=Very poor; P=poor; F=fair; G=good; VG=very good.

[6] Cr=cream; Cy=creamy yellow.

EFFECT OF AWN TYPE ON YIELD AND KERNEL DEVELOPMENT

Annual and total comparisons of awned and awnless types are presented in table 2. The mean advantages for awns over awnless are obvious and are usually significant as judged by the "number of times superior." The weighted 3-year means, as indicated by the *t* values, show highly significant superiority for the awned forms of both Baart and Onas in all characteristics. The yields and test weights were generally above average in 1943 and below average in 1945.

The data here presented, together with those previously reported,[9] seem conclusive in showing that awns generally increase yield, individual kernel weight, and test weight in the Western States, regardless of yield level and whether grown under irrigation or on dry land.

Quality data for the awned and awnless strains of Baart and Onas are presented in table 3. These data were obtained with comparably grown composited samples. The derived-awn types are generally similar to their parental strains in chemical, milling, and baking quality, or where different the differences are so small that they are unimportant.

DISCUSSION

Baart is one of the most extensively and diversely grown white wheats.[10] Its distinctive large kernels and high test weight make it popular for special commercial uses. The substitution of Awnless Baart would result in a reduction in yield, kernel size, and test weight and might mean a loss of the special market for Baart.

Onas, on the other hand, although widespread, has achieved only limited production,[10] primarily because of its low test weight. The larger yield and heavier test weight (nearly 1 pound per bushel) of Awned Onas might result in an appreciable improvement if the awned strain were distributed to farmers. Further experimentation with these two Onas stocks will be necessary before recommendations can be made.

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[9] See footnote 2.

[10] CLARK, J. A., and QUISENBERRY, K. S. DISTRIBUTION OF THE VARIETIES AND CLASSES OF WHEAT IN THE UNITED STATES IN 1939. U. S. Dept. Agr. Cir. 634, 75 pp., illus. 1942.

U. S. GOVERNMENT PRINTING OFFICE: 1948

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